Macrophytes

and

Eutrophication in Oyster Pond

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ABSTRACT: Land-derived sources of nitrogen from wastewater, fertilizer and atmospheric deposition are thought to be driving the widespread eutrophication that is thoroughly altering structure and food web of coastal environments. The impact of nutrient loading to Oyster Pond, a coastal lagoon on the shore of Cape Cod, has been a source of concern for the residents in the area for over three decades (Emory 1997). We chose to examine the macrophyte population in Oyster Pond as an indication of wastewater nitrogen load coming into the pond. We found that the species that were most abundant in our survey coincide with the dominant species found in eutrophic lakes (Schneider and Melzer 2003), and that the macrophytes found in Oyster Pond, in particular non-rooted species, are good indicators of wastewater nutrient loads at incipient levels.

Introduction

Eutrophication is one of the most widespread and pervasive agents of ecological change in coastal environments (GESAMP 1990, NRC 2000). Land-derived sources of nitrogen from wastewater, fertilizer and atmospheric deposition are thought to be driving the widespread eutrophication that is thoroughly altering structure and food web of coastal environments (Valiela et al. 1997, Valiela and Bowen 2002).

To assess the environmental changes forced by increasing nutrient enrichment, researchers have sought and found a variety of indicators, including key variables such as chlorophyll and nutrient concentration, species richness, key sentinel species, biotic integrity indexes, and so on (U. S. Environmental Protection Agency 2003). Recently, stable isotope signatures have been used to detect eutrophication, even at incipient levels (Hansson et al. 1997, and S. McClelland et al. 1997, McClelland and Valiela 1998). The δ^{15}N of nitrate can be used to ascertain the relative contribution from different N sources (wastewater, for example - Table 1), owing to differential fractionation during the transport after release of the nitrogen. McClelland et al. (1997) and others (Wigand et al. 2001, Cole 2003) have suggested that $\delta^{15}N$ of macrophytes is closely linked to total N load, and to wastewater nitrogen from land. Macrophytes are good indicators of eutrophication because they are widespread, long-lived, and store nitrogen in tissues.

Oyster Pond is a coastal lagoon on the shore of Cape Cod that has gone through numerous changes in salinity and development over the years. In estuaries on Cape Cod and around the world, an issue of great concern is the nutrient load entering the estuary from land, primarily nitrogen from waste water. Eutrophication, caused in part by increased nitrogen load, is a leading agent of change in coastal waters. Land use changes, especially the addition of housing developments, often result in an increase of nitrogen load delivered to an estuary. Around Oyster Pond, development within each sub-watershed could potentially increase the nitrogen load that is delivered to Oyster Pond, especially in the recently developed area of Treetops at the northern end of Oyster Pond.

In Oyster Pond, there is particular concern over whether the wastewater nitrogen from the Treetops development is resulting in an increasing abundance of nuisance macrophytes in the pond. We have chosen to focus on submerged aquatic vegetation, both rooted and non-rooted, due to its abundance and location within Oyster Pond. Previous research has used isotopic signature of nitrogen ($\delta^{15}N$) in macrophytes to determine the source of nitrogen entering an estuary, as certain values have been assigned to specific nitrogen sources (Table 1). A previous study has indicated that $\delta^{15}N$ values of non-rooted macrophytes in Oyster Pond are good indicators of nitrogen loading (2002 study pers. comm.).

Methods

The Oyster Pond watershed has been divided, by previous researchers, into 6 sub-watersheds in which groundwater displays significant differences in nitrogen load (Fig. 1, Grady and Muto 2001). To obtain samples of plants that were exposed to the different nitrogen loads delineated for the sub-watersheds of Oyster Pond, we collected macrophytes from fifteen locations along the shoreline of Oyster Pond. At each location, we collected samples of every species present. The species were identified and the fronds were then rinsed in deionized water to remove pond water. Each sample was dried in a 60°C drying oven for three days then ground to a fine powder, weighed, and prepared for analysis. The $\delta^{15}N$ values of the fronds were measured using the Continuous Flow Isotope Ratio Mass spectrometer at the Stable Isotope Facility of the University of California at Davis.

We combined our data with data from macrophyte studies in 2001 and 2002 (Grady and Muto 2001, 2002 study pers. comm.) and compared $\delta^{15}N$ to N-load in the watershed area where the plants were collected. The N-load values were calculated for 2001 and 2002 using the NLM N-load model developed by Valiela et al. (1997) (Grady and Muto 2001, 2002 study pers. comm.). The isotope data from each year (2001, 2002, 2004) were combined in order to examine differences in macrophyte $\delta^{15}N$ signatures between years.

Results and Discussion

We collected forty samples from 15 sampling sites, which we identified as six species. We found no significant difference in $\delta^{15}N$ signatures between years, however our results show that there is a significant increase in δN^{15} values in all macrophyte samples collected from 2001-

2004 when plotted against measured N-load data (Fig. 2). There was a larger difference in $\delta^{15}N$ signatures of macrophytes at lower N loads, which indicates that macrophytes in Oyster Pond are a good indicator of eutrophication at incipient nitrogen loads.

There was a significant increase in $\delta^{15}N$ in response to N load in both floating and rooted plants ($P = 0.015$, $P = 0.049$, respectively). A previous study done in Oyster Pond in 2002 indicated that while non-rooted macrophytes are a good indicator or nitrogen loading, rooted macrophytes may not be the most effective indicators of N load (2002 study pers. comm.). However, our results, when pooled with the results from previous years, indicate that the δN^{15} of rooted, submerged aquatic vegetation does increase with wastewater-derived N-load (2002 study pers. comm.)(Fig. 3).

There appears to be some anecdotal evidence indicating that there has been a change in species composition from 2002 to 2004, which can be seen in Table 2. The main apparent change in species composition was the difference in the amount of coontail observed, *Ceratophyllum demersum*. While this macrophyte has been documented in Oyster Pond sine 1969 (Emory, 1997), its year to year presence appears to be variable. The 2001 Oyster Pond study did not find large amounts of this macrophyte and the 2002 study did not even include data for *C. demersum* in their results. Previous research has not included *C. demersum* in distribution and percent cover surveys of Oyster Pond, however we found *C. demersum* to be one of the most prevalent macrophytes within the pond. Hough et al. (1989) found that in most of the nitrogen enriched lakes they examined, non-rooted macorphytes, specifically *C. demersum*, were dominant. An increase in *C. demersum* is a condern due to its ability to increase shading and decrease light availability for rooted plants (Tracy et al. 2003). It would probably be of interest to the residents of Oyster Pond to continue to monitor the presence of *C. demersum* in the coming years.